**Climate Ready Estuaries Partner Profile**
**Albemarle-Pamlico National Estuary Program (APNEP)**

The gradually sloping shores of the Albemarle and Pamlico Sounds comprise more low-lying land within 1.5 meters of sea level than any other national estuary. The system is particularly vulnerable to the effects of sea level rise. Barrier islands such as the Outer Banks are also at risk from erosion and storm surges. The Albemarle-Pamlico National Estuary Program (APNEP) recognizes the need to communicate these risks to the public and policymakers, and has begun to facilitate a regional conversation about how best to address climate change.

APNEP partnered with the Albemarle-Pamlico Conservation and Communities Collaborative (AP3C) to host a series of seven public listening sessions throughout the estuary region. Residents from a variety of backgrounds attended these sessions to voice their concerns about the combined impacts of sea level rise and population growth, and to offer ideas about potential solutions. In gauging public perceptions, APNEP and AP3C found a high level of awareness and a thirst for more information. The estuary program plans to continue improving public outreach and education efforts to respond to the APNEP watershed community's evolving needs.

> "We are working to make connections and to facilitate the conversation on climate change and possibilities for action."
>
> -Bill Crowell, Director, APNEP

APNEP is also engaging directly with policy makers. The program is working with the Nicholas Institute for Environmental Policy Solutions at Duke University to interview local and state elected officials. The interviews will gauge officials' understanding of climate change issues and the actions they are taking to address challenges. Findings will be used to develop a needs analysis and form the basis of a climate change and adaptation communication strategy for local policy makers.

APNEP is participating in a number of other partnerships with state agencies and nonprofit organizations to assess and address the vulnerability of infrastructure and habitats to sea level rise. APNEP plays a key role in connecting people, using its understanding of the unique strengths of each partner to facilitate meaningful discussion in the region.

Learn more about the Albemarle-Pamlico National Estuary Program at http://www.apnep.org/.

**Climate Ready Estuaries Partner Profile**
**Charlotte Harbor National Estuary Program (CHNEP)**

The expansive Charlotte Harbor in southwest Florida experiences unusually large fluctuations in river flows between wet and dry seasons: in winter water flows decrease to about one-quarter of summer volume. These dramatic swings in freshwater flow—driven by seasonality coupled with a low, flat topography—strongly affect water quality and habitats for fish and other wildlife. They also make the harbor particularly susceptible to the effects of climate change.

Sea level has been rising at a rate of about 0.8 to 1.2 inches per decade along the Gulf Coast, and relative rise is more severe where land is subsiding.[1] Rising seas will continue to exacerbate serious flooding risks when combined with increasingly "flashy" precipitation and more intense tropical and regular seasonal storms.

The Charlotte Harbor National Estuary Program (CHNEP) is conducting a climate change vulnerability assessment for southwest Florida in partnership with its host agency, the Southwest Florida Regional Planning Council (SWFRPC). Slated for completion by November 2009, the vulnerability assessment incorporates Sea Lake and Overland Surges from Hurricanes (SLOSH) modeling to assess storm surge. Use of the SLOSH model has already improved land use decisions, infrastructure investment, and conservation management in the region.

> Impressed by the level of public interest in addressing climate change, CHNEP Director Lisa Beever notes, "Active public meetings with creative and well-planned activities are vital to the community-driven adaptation planning process. The use of public participation activities increases the ability of citizens to provide detailed ideas and priorities."

In December 2008, the Punta Gorda City Council voted unanimously to partner with CHNEP's 2009 pilot adaptation planning effort. This initiative has benefited greatly from the energy and support of the citizens of Punta Gorda, Florida, including a grassroots volunteer group to help rebuild the city, born out of the devastation of Hurricane Charley. Adaptation planning to date has included two successful public workshops. These workshops built upon a pre-meeting survey and include interactive exercises to engage the public in helping to consider and prioritize vulnerabilities and adaptation strategies. A third public workshop scheduled for late 2009 will present the draft adaptation plan and provide an opportunity for public comment.

CHNEP and SWFRPC recently evaluated the Southwest Florida Feasibility Study (SWFFS) in the context of climate change. The SWFFS supports the development of a water resources

[1] National Science and Technology Council. 2008. Scientific Assessment of the Effects of Global Change on the United States. Prepared by Committee on Environment and Natural Resources, Washington, D.C. Prepared for U.S. National Science and Technology Council. 271 pgs.

plan for the entire southwest Florida region and is a key component of the Comprehensive Everglades Restoration Plan—the largest environmental restoration program in history. CHNEP's collaborative efforts help to ensure that estuary efforts and these broader activities together will enhance climate change resilience in the region.

Planned future activities include the development of environmental indicators to assist in monitoring climate-related changes and gauging the success of adaptation strategies, as well as the development of model ordinances for local and regional governments in Florida. CHNEP is also preparing a study to assess the vulnerability of southwest Florida salt marshes to climate change and identify opportunities for adaptation.

Learn more about the Charlotte Harbor National Estuary Program at www.chnep.org.

**Climate Ready Estuaries Partner Profile**
**Massachusetts Bays Program (MBP)**

The Massachusetts coastline is at risk from climate change and its interactions with pre-existing threats such as pollution and invasions by non-native species. For example, changes in precipitation patterns can alter freshwater flow, which could in turn lead to changes in nutrient or pollution concentrations and allow invasive species to expand their ranges.

In October 2008, the Massachusetts Bays Program (MBP) launched a climate change vulnerability assessment in partnership with EPA's Global Change Research Program. The assessment concentrates primarily on the sensitivity of salt marsh ecosystems to projected impacts of climate change. The MBP will share its enhanced understanding of salt marsh vulnerability and related management implications with partners at the community, state, regional, and federal levels. This ecosystem-focused study will complement work being done by the Massachusetts Office of Coastal Zone Management's StormSmart Coasts Program, which addresses the vulnerability of infrastructure and coastal property to the impacts of climate change.

> "We anticipate that our improved understanding of the vulnerability and sensitivity of coastal wetlands will enhance our capacity to manage these important and valuable resources."
>
> -Carole McCauley, Outreach and Policy Coordinator, MBP

Soon after embarking on its vulnerability assessment, the MBP established a climate subcommittee to identify a meaningful role for the MBP in climate change adaptation planning, including how the MBP might best contribute to the state's adaptation planning efforts led by the Massachusetts Executive Office of Energy and Environmental Affairs.

The subcommittee decided that MBP's first step should be to assess the needs of its constituent coastal communities with regard to climate change. The needs assessment will identify the degree to which communities are interested in and equipped to undertake adaptation planning. Results from the assessment will be shared with interested parties, thereby promoting the interests of coastal communities.

Learn more about Massachusetts Bays Program at http://www.massbays.org.

**Climate Ready Estuaries Partner Profile**
**Partnership for the Delaware Estuary (PDE)**

The Delaware Estuary watershed is characterized by a complex balance of habitats and living resources. Tidal marsh habitats line much of the Delaware Estuary and play a pivotal role in preserving water quality, preventing flooding, and supporting fish and wildlife species. However, the health of these tidal marshes appears to be compromised over much of the region, and climate change may worsen existing stresses on the Delaware Estuary.

The Partnership for the Delaware Estuary (PDE) is conducting vulnerability assessments and will develop adaptation plans for three "case study" resources: drinking water, tidal wetlands, and shellfish—selected as focus areas because they are important to the vitality of both people and the environment, and because they are potentially vulnerable to the effects of climate change. The assessments will focus on how these resources may be affected by increases in temperature, salinity, precipitation, heat waves, and storms. While hampered by gaps in key data and monitoring, PDE is moving forward to identify areas where data are available and to develop descriptions of vulnerabilities that cannot currently be quantified.

PDE has also created a team to estimate the value of losses in natural capital from climate change and determine how these losses might be reversed or improved through restoration. Through the three case studies, the team plans to demonstrate how ecosystem services valuation can be used in adaptation planning.

*Drinking Water*

The Delaware Estuary and its watersheds provide drinking water for about 16 million people. Drinking water is threatened mainly by increasing salinity in freshwater tidal areas. The Philadelphia Water Department worked with PDE to conduct a literature review identifying the drinking water resources around Philadelphia most likely to be at risk from changing climate conditions. A draft list of potential vulnerabilities is now under review.

> "We decided it was better to focus on case study areas first and then move up to a more comprehensive picture of climate change impacts and adaptation in the estuary."
>
> – Priscilla Cole, Science and Policy Fellow, PDE

*Tidal Wetlands*

Tidal wetlands are already being affected by climate change. PDE is working with several partners to analyze the impacts of sea level rise on tidal wetlands and ecosystem services in the Delaware Estuary. This analysis will estimate the quantity and value of coastal ecosystem services at risk, and develop adaptation strategies for improving resiliency.

*Shellfish*
The vulnerability of bivalve shellfish to climate change differs between non-tidal and tidal areas. All species of shellfish in the Delaware Estuary, especially oyster populations, are at risk. PDE is researching and modeling the vulnerabilities of bivalve shellfish to changing climate conditions. Graduate students at both Rutgers and Drexel University are working with PDE to predict the response of oysters and mussels to climate change and investigate potential restoration options.

This work will aid PDE in developing an adaptation plan by providing information related to the vulnerability of various habitat types and ecosystem services, options for improving resilience, and additional considerations for estuarine restoration.

Learn more about the Partnership for the Delaware Estuary at http://www.delawareestuary.org/.

**Climate Ready Estuaries Partner Profile**
**Piscataqua Region Estuaries Partnership (PREP)**

Piscataqua Region Estuaries Partnership (PREP) manages New Hampshire's two main estuaries: Great Bay and Hampton-Seabrook. These estuaries face threats such as rising nitrogen concentrations, growth in the area of paved and other impervious surfaces, a substantial decline in standing oyster stocks, and increasing storm severity associated with a changing climate.

Intense and destructive flooding in New Hampshire in 2006 and 2007 heightened regional awareness of the threats associated with climate change. Both floods were caused by unusually heavy rain events, one occurring over a heavy snowpack and another over snow-free ground in late spring. The runoff from these events overwhelmed existing road and stream culverts, highlighting the need for planning to prepare for projected increases in storm severity.

PREP launched a pilot Climate Ready Estuaries project in 2008 to identify road culverts in the Oyster River watershed that are susceptible to failure in the face of increasingly severe storms and from hydrological modifications related to development in the watershed. A similar project had already been carried out successfully in southwestern New Hampshire; PREP seized on the opportunity to replicate that approach in a coastal setting and kick off its effort to address climate change by tackling one threat rather than several. PREP anticipates that its culvert assessment findings will generate greater interest in addressing climate change across the estuary region.

> "Citizens and community leaders need to understand that climate change impacts are already happening and will only get more severe over the next 50 years. We can proactively plan for and adapt to those impacts now, or wait and react to them as they play out in our communities and incur much greater environmental and economic costs."
>
> -Derek Sowers, Director, PREP

PREP began the assessment by completing a comprehensive inventory of significant culverts in collaboration with the town of Durham and the Strafford Regional Planning Commission. Most towns do not maintain a comprehensive inventory of the locations and capacity of culverts; identifying the locations of the culverts proved challenging but not impossible. The team used data on culvert capacity, vegetation cover, slope, soils, and land use to create a geographic information systems (GIS) model that calculates the amount of runoff expected from major precipitation events. The researchers then used climate model projections to estimate the magnitude and average interval of occurrence of storm events in the mid-21st century under two greenhouse gas emissions scenarios. Finally, the team used these future precipitation estimates as inputs to the GIS runoff model to identify which culverts will be most vulnerable to increased precipitation.

A key finding that PREP plans to convey to decision makers is that all future precipitation projections for the area point toward additional strain on the existing culverts. PREP plans to communicate the project findings to decision makers and the public using maps to show each culvert's ability to handle projected precipitation events. Project findings will be used to inform decisions about culvert maintenance and upgrade options.

Learn more about Piscataqua Region Estuaries Partnership at http://www.nhep.unh.edu/.

**Climate Ready Estuaries Partner Profile Outline**
**San Francisco Estuary Partnership**

Sea level along the California coast has risen nearly eight inches over the past century and is projected to rise by an additional 20 to 55 inches by 2100.[1] Today's 100-year flood plain is estimated to roughly equal a mid-century high tide. The Bay Area Conservation and Development Commission (BCDC) predicts that people, businesses, and infrastructure located in the current 100-year flood plain, thus, face a 100 percent chance of flooding by 2050.[2] The Bay ecosystem is at risk because of these and other climate-related changes, including wetland inundation and erosion, altered species composition, changes in freshwater inflow, and water quality impairment.

> "There are a host of climate change-related activities moving at 'light speed' in the Bay Area. Our hope is that the CRE vulnerability assessment is a building block that supports these activities."
> *Judy Kelly, Director, SFEP*

The San Francisco Estuary Partnership (SFEP) and its host agency, the Association of Bay Area Governments (ABAG), are working to address climate change regionally as part of a coordinated effort led by the Joint Policy Committee (JPC)—an organization composed of ABAG, the Bay Area Air Quality Management District, BCDC, and the Metropolitan Transportation Commission.

In the context of sweeping regional action on climate change, SFEP launched a climate change vulnerability assessment in partnership with EPA's Global Change Research Program. The assessment concentrates primarily on the sensitivity of salt marsh ecosystems to projected impacts of climate change. SFEP and BCDC kicked off the effort in October 2008, hosting a workshop convening Bay Area scientists and resource managers to discuss ecosystem vulnerability and to share ongoing research.

The assessment is considering how changes in climate drivers (such as temperature, precipitation and storms) may affect salt marsh ecosystems. For example, climate-induced changes in hydrology and sea level can affect sedimentation, erosion, and inundation of salt marshes.

A second workshop in early 2010 will convene technical experts to characterize the sensitivity of salt marsh sediment dynamics (accretion and erosion) and species interactions (plants and animals) to projected changes in a variety of climate-related

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[1] Cayan, Dan, M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2008. Climate Change Scenarios and Sea Level Rise Estimates for California 2008 Climate Change Scenarios Assessment. California Climate Change Center. CEC-500-2008-014-F. [As cited in: San Francisco Bay Conservation and Development Comission. 2009. Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline]

[2] San Francisco Bay Conservation and Development Comission. 2009. Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline.

stresses. Gaining a better understanding of how climate change will affect existing ecosystem processes will inform the development of adaptation strategies.

Learn more about the San Francisco Estuary Partnership at http://sfep.abag.ca.gov/index.html